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THE SELECTION, DEVELOPMENT AND TESTING OF AN INTEGRATED TRUCK/SHOVEL MANAGEMENT SYSTEM

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SELECTION, DEVELOPMENT AND TESTING OF AN INTEGRATED TRUCK/SHOVEL MANAGEMENT SYSTEM

by

V. Srajer*, L. Hick**, W. Sadler***

ABSTRACT

The development and field testing of an Integrated Truck/Shovel Operating and Management system is described in this paper. A total of eight mining companies in western Canada have provided data for validation of the computer model; a system for on-board data acquisition has nov been selected and tested at a producing surface coal mine in Alberta and the truck/shovel management system has been defined and is under development. The system consists of a computer simulation program, a dispatching program, an equipment information system, a data transfer system, a data base system, and mobile equipment location devices. The system components are proposed to be field tested in a both stand-alone and fully integrated mode.

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SÉLECTION, DÉVELOPPEMENT ET CONTRÔLE D'UN SYSTÈME DE GESTION INTÉGRÉ DES CAMIONS/PELLES

par

V. Srajer*, L. Hick**, W. Sadler ***

RÉSUMÉ

Les auteurs présentent une description du développement et du contrôle sur le terrain d'un système de gestion et d'exploitation intégré des camions/pelles. Dans l'ensemble, huit sociétés minières de l'Ouest canadien ont fourni des données pour la certification du modèle informatisé; un système de collecte de données à bord des camions a été sélectionné et vérifié dans une mine de charbon à ciel ouvert en exploitation en Alberta et est en développement à l'heure actuelle. Il comprend un programme de simulation par ordinateur, un programme de répartition des camions, un sytème d'information sur l'équipement, un système de transfert des données, un système de base de données, et des dispositifs de repérage de l'équipement mobile. Les différentes partie du système doivent faire l'objet d'un contrôle sur le terrain, individuellement et en mode intégré.

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INTRODUCTION

Efficient mining operations using truck/shovel mining systems are dependent on proper allocation of trucks to shovels and the respective allocation of trucks to the loading equipment and to dump sites. Due to equipment breakdowns, varying digging conditions and truck capacity, and coal blending considerations, frequent truck re-allocations are required to maintain an efficient operation. Mine production and operating personnel must maintain an up-to-date awareness of the operations in the mine, and must circulate continually around the active areas in the mine to observe and allocate trucks as required.

The often harsh Canadian climate creates many problems in conducting efficient surface mining operations. Fog, rain, sleet and snow cause problems for all vehicles at the mine; visibility may be reduced to only a few meters making vehicle maneuvering extremely dangerous. Trucks must reduce their speed considerably, to the extent that mine production is reduced or stopped completely.

To reduce the risk and improve mine productivity, systems for on-board data collection, vehicle dispatch and instantaneous status / location reports for mobile equipment are required.

This paper is based on several studies conducted jointly by CANMET with the coal mining industry in Canada (Srajer and McConechy, 1987). The requirement for the system was formulated and an on-board data collection system selected and tested. Existing dispatching programs, equipment monitoring, positioning and data transfer systems were proposed to be used as components of the integrated management system. In essence the computer simulation program will take equipment information and location system outputs relayed by the data transmission system, conduct simulations, apply the logic of the dispatch program and inform equipment operators of dispatch decisions.

FORMULATION OF REQUIREMENTS

The primary objective of a control system is to order truck movements to minimize truck waiting time at the shovels and ensure that the quantities of

material loaded from different areas of the pit are maintained in strict ratios to meet the predetermined tonnage and blend requirement. The secondary objective is to ensure that maximum waste material is hauled from various pit areas in an order of priorities established by mine planning engineers to meet predetermined coal/waste stripping ratios.

Considerations affecting these principal objectives may include:

- shoveling capacity will always exceed trucking capacity, therefore, truck queuing is avoidable,
- proper blending of the coal may be of primary importance,
- distances travelled by coal haulers from pit exit to storage pile or crusher are fixed by pit design, only distances travelled in the pit and waste hauling distances are variables,
- satisfactory control of truck movement may be achieved if the required digging rate for each shovel is specified and if a logically correct decision is made for the dispatch of each truck so as to achieve the predetermined balance of material moved from the pit, and
- system must be flexible to account for breakdowns of trucks and shovels and unexpectedly difficult or easy digging and hauling conditions.

The simulated activities at the mine planning stage consider a mine that is in production. The simulation will use the same times for any event, irrespective of the number of times the event occurs (averages as determined by the first model). Options should allov a user stipulation that events have a statistical distribution with means and standard deviations as supplied by the user. This may be important at mines with only time study data available. The user may also elect to incorporate breakdowns, relocation of equipment, changes in production requirement, etc.

In the dispatching module, the user may simulate the dispatching of the trucks in an automatic or semi-automatic mode. In automatic dispatching, the computer makes a decision where to send a truck immediately following the loading or dumping operation. In semi-automatic dispatching, each truck may be allocated to either a specific shovel or a specific dump point at the start of the simulation. The computer will then select, for each truck, only the appropriate (permissible) loader or dump. Further, trucks might be restricted to both a nominated shovel and a nominated dump.

The model must be interfaceable with the user at any time during the simulation process. The user may interrupt the simulation and to reviev

displayed options. These options may include proposed changes in truck allocation, breakdowns, delays planned or requested, repairs, shovel delays, etc., all delays will then by specified by the number of minutes of delays and start of the delay.

The model simulation must determine the disposition of all equipment at any given time. Breakdowns for trucks and shovels are considered and alternative allocations due to such changes are implemented. A record of machine inventory, location, specification ,etc., should be maintained and be easily recoverable from the model for any specified period of time.

The program simulation output is proposed to be in four forms: automatic and requested display, and automatic and requested reporting. Currently most potential users appear to be interested in automatic display only, when the dispatch system is used.

The provision for warning, recording of warned events and response to the warned events, must be incorporated in the model. This warning system will come from the field, when special attention is needed from operator, dispatcher, pit foreman, mine manager.

It is proposed to develop an independent system of vehicle positioning that is not dependent on any haulage 'marking' system. The dispatcher must be able to provide guidance to the operator, or provide warning to the operator about obstacles in front of him. The operator must also be informed about his location and should be guided to his next assignment by a simple graphical display in his cab.

In addition to the positioning component of the system, route maps and a digital terrain model must be developed and integrated. A route digital map (in vector digitizing) is proposed to be used for both vehicle positioning and real-time optimization and scheduling. The scheduling processes will assign vehicles to loading or dumping points, optimization processes will select the optimum route for vehicles to follow. The route will then be displayed to the truck operator, giving him vehicle location and direction of travel. It will inform him about next turns, stoppages and obstacles in front of him, or any other relevant information.

The computer database of the functional system is expected to be structured on a relational model of a route network where roads are links and stations and facilities are nodes. The choice of database model saves a

significant amount of storage of the main computer and may be readily updated. The database is expected to be also used as the main framework in determining real time, optimal scheduling and allocation. Dynamic scheduling is expected of the system, including changing parameters of the haulage network, changes in rolling resistance of the road surface in relation to weather, etc.

The mine modelling system must be therefore able to use average and randomly collected data to simulate future events and to predict event distribution and frequency, and also use real time data as collected by the vehicle management system or vehicle positioning system to optimize mining processes.

TRUCK MANAGEMENT SYSTEMS

Review of On-board Systems

Existing truck monitoring systems evaluated on the North American market were reviewed (Srajer, 1986). The systems evaluation was based on function, diagnostics and integrated system controls. An abridged version of this overview is presented here.

The non-operator dependent on-board truck data collection and evaluating systems were recognized as having the greatest potential for installation on mining trucks in Canadian surface coal mines.

Five on-board data collection systems were investigated. They are the TSS, developed by Dynafloat Inc., a subsidiary of Unit's Rig Co. of Tulsa, Oklahoma, the TIACS, developed by TRW Transportation, Electrical and Electronics Operations Division of Solon, Ohio, the VMS, developed by GLI Corporation, a subsidiary of Baker Mining Equipment Company of Woodinville, WA., the ETEC, developed by TRW of Farnington Hills, Michigan, and the OBDAS, developed by Philippi-Hagenbuch, Inc. of Peoria, Ill.

TSS is used for bench testing of the electronic control panels for General Electric Reliance systems used in various trucks. It consists of four subsystems which provide critical information on inspection for truck manufacturing problems, product component failure, warranty reports, and quality analysis reports. The functional and diagnostics controls are combined into integral control systems. The truck dispatching uses a direct message system to control allocation of trucks and at the same time collects data on the driver's performance and vehicle utilization.

TIACS is an innovative vehicle monitoring system having the following unique characteristics:

- time-sharing of system components,
- multiple uses by individual operators,
- easy modification of the existing system,
- recording and monitoring capability for diagnostic and maintenance,
- programmed overhauling schedules, and
- system flexibility for options.

The basic element of the system is the Serial Communications Link used for data transfer between vehicle sensors, actuators and control systems (Fig. 1).

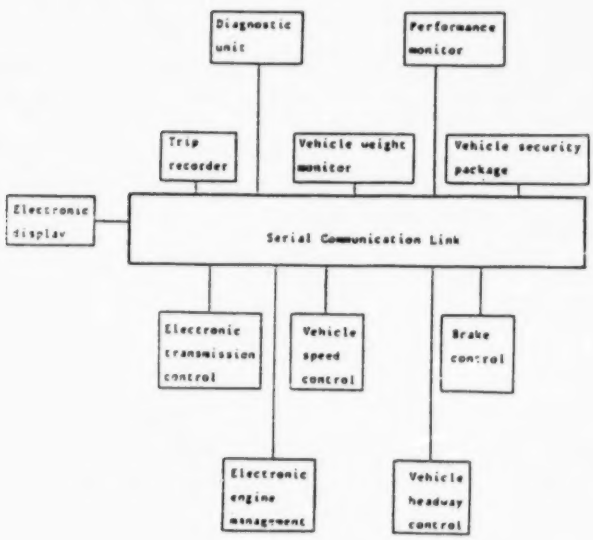

Fig. 1. TIACS System Components

VMS was introduced as a preventive maintenance tool to reduce downtime and repair cost. The system consists of a microprocessor based unit that continuously monitors engine, drive train and all vital functions including pressures, fluid levels, temperatures, electrical outputs, RPM and speed of the vehicle. The system will inform the operator about the nature of the problem and recommend action to be taken.

ETEC is an integral part of the Automatic Truck Control system that provides control for vehicle speed, module and cruise controls, and engine speed limiter for most fuel efficient gear at all times. Installed electronic recorder produces reports on elapsed travel and idle times, average travel speed, trip summary report and trip faults report. The system was installed and tested on Unit Rig's M-100 haulers. The basic system consists of on-board equipment and wayside equipment. The wayside equipment is a buried guidewire block control unit and central controller, which provides predetermined signals to the on-board equipment for speed control, steering and auxiliary functions, and also location of vehicle to a central display panel.

OBDAS consists of an automated data gathering system, forming factor-building blocks, such as weighing, time and motion study, maintenance management, as well as truck dispatch (Fig. 2). Central to the OBDAS system is an on-board micro processor, used to manipulate input signals and provide output essential for equipment performance monitoring. The processing unit used by the system is a Motorola 68HC11, capable of receiving both digital and analogue input signals and time relating these signals using a built-in clock.

OBDAS's primary on-board sensing function is weight or payload monitoring. It is through this function that the most direct benefit, through cost savings, can be realized by a mining operation. The OBDAS weighing system features four load sensors installed on the truck frame and forming the contact area for the box rails. The pressure transducers, one for each load sensor, are mounted outside the cab of the truck and provide a voltage signal (varying with pressure) to the micro processor. A floating cap channel with an inside contact plate having a specific area sits on top of the hose assembly. By applying the area of the contact plate to the pressure created in the hose by the truck's load, the weight being carried is produced.

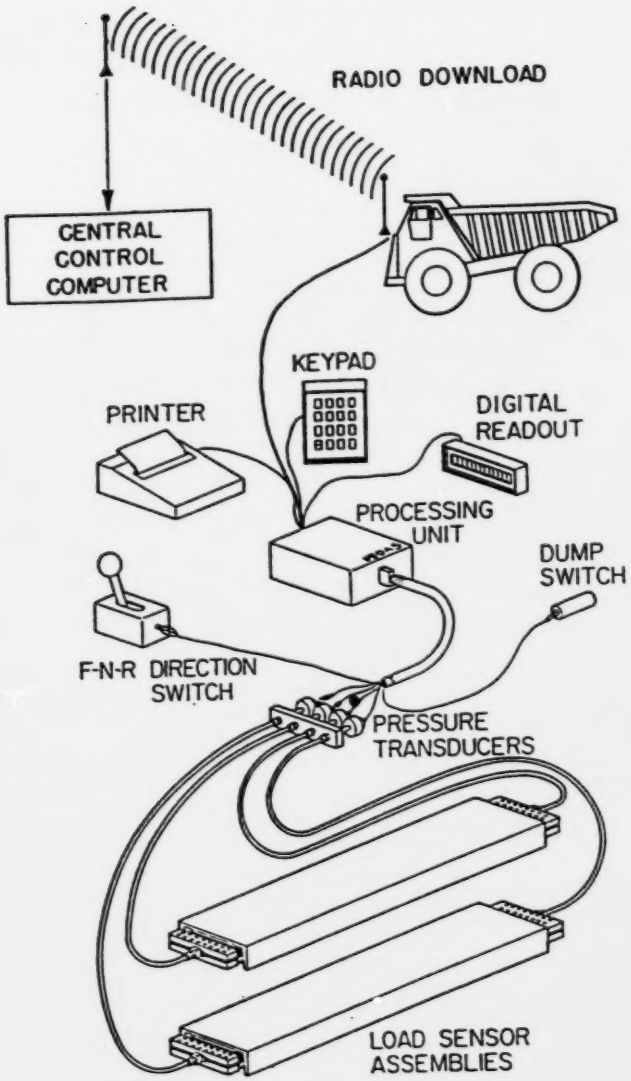

Fig. 2. OBDAS System Components

The OBDAS collects the information required to complete a time study of each haul cycle; including times for loading , travel full, dumping, travel empty, and waiting. This is achieved by combining the built-in clock feature of the processor with input signals received from additional OBDAS hardware.

Additional on-board output includes a printer that is used as backup for data collection, gathering road profile information when required, and running diagnostic checks on the system.

The OBDAS was selected for field tests in a cooperative project between CANMET and Gregg River Resources at their mine near Hinton, Alberta (Gould, McConechy, Srajer, 1988). The installation of the system on two trucks has resulted in overall saving of $ 240,000 annually in handling 12 Million bcm of waste. This calculation is based on increased truck productivity since the system introduction. The average load per cycle for OBDAS equipped trucks increased from 55.3 to 57.3 bcm. The initial capital expenditure was $ 60,000 for hardware installed on two trucks plus radio communication. Equipping the remaining six trucks in the waste haulage fleet will add another $ 100,000 to the capital cost. The weigh studies indicate that the two trucks having OBDAS are carrying a greater payload than trucks without OBDAS; expanding the system to cover the entire fleet should therefore further increase savings.

Truck Dispatching Systems

Several manual, semi-automatic and automatic dispatching systems are used by Canadian mining companies. Semi-automatic systems are presently working at Quebec Cartier (QCL) mine in Fermont, Quebec, and at Lac d'Amiante du Quebec mine in Thetford Mines, Quebec. The first (QCL) was developed by the Ecole Polytechnique and the second one is under development by the Department of Mining and Metallurgical Engineering of McGill University.

Commercially available systems employed in Canada are:

- Motorola's Data Ranger Communication and Computerized Dispatching System introduced at Syncrude mine in Ft. McMurray, Alberta,
- Modular Mining Dispatch System at Iron Ore Company (IOC) Carol Project mine in Labrador City, Newfoundland, and at Quintette mine in Tumbler Ridge, British Columbia,
- Glenayre Electronics MIDISS System installed at Lornex mine near Logan Lake, B.C. (the system is no longer operational),

- Wenco's Production Monitor and Control System (PMCS) at Suncor mine in Ft. McMurray, Alberta, Balmer and Greenhills mines in Sparwood, B.C., and on trial at Wabush mine in Wabush, NFLD.

All systems were investigated in detail, mine operators were interviewed and system performance and price were compared. The PMCS dispatching system was used as a base for the development of an Integrated Truck/Shovel Management System.

The PMCS is comprised of custom designed data gathering and encoding hardware with the ability to receive and transmit data mounted in production equipment, radio repeaters when needed, a radio communications system interface, a twin microcomputer based dispatcher and pit monitor display, and a similar microcomputer that provides current and historic management information.

Equipment operators are provided with a dash mounted dataset with several function keys which must be touched at predetermined (assigned) points in each production cycle. The signals generated are received by a custom designed modem that translates messages between the languages of the base radio and the computer. The modem continuously runs a firmware set whose function is to determine that the message received is meaningful and to accept and acknowledge valid messages. These messages are then passed on to the Monitor computer.

Where there is a need, optional fixed point location monitoring functions are used to validate or extend the information available to the system. To automatically trigger a shovel assignment is a typical use of this function.

PMCS includes an optional automatic truck dispatching function that may be used at the discretion of the pit control supervisor. By linking a group of shovels that are working in reasonable proximity to one another as a set, trucks assigned to the set are directed to the particular shovel, using the mobile dataset, based on the first of the linked shovels that will be ready to serve this truck. The dispatch decision is made by the computer on the basis of presently assigned units, priority, status, as well as observed loading and cycle times among the shovels and trucks of the set. The capability is also provided for the dispatcher to assign a truck through the computer keyboard.

Decision support for the first line supervisor is provided through the Monitor program. This program receives its data by drawing messages from the radio modem whenever there are any to be read. It presents a display, continuously updated, that show events in the mine as they occur.

The pit control supervisor, or dispatcher, is given a tool to improve mine productivity through such things as accurate knowledge of truck and shovel waiting times in each setup, calculated optimum trucking levels and both the planned and actual blend produced during the present operating period. The status of each set is known, as well as the cycle segments in which each unit is now operating or, if it is delayed, the nature of that delay. Cycle times and parts of cycle times are known by unit. Production and forecast production are presented.

Monitor program provides error trapping and correction capability to ensure that end of shift results are accurate before they are passed to the user, the Management Information module of PMCS, or to external Accounting or Management Information systems. The Monitor program computer also runs a set of system maintenance programs that provide the tools to make and modify assignments, blend requirements and an assortment of assignment and relationship tables used by Monitor program, as well as to enter certain operating data to complete the system's knowledge of production events and results achieved during the shift.

All significant production information has been electronically recorded during the course of the shift, these results can be displayed in a comprehensive shift report. The shift report aids in the process of handling the mine from one crew to the next and provides preliminary shift performance details. Equipment in use, or available, and present assignments, are set out in a form to help the oncoming shift supervisor assign his crew most effectively. In addition, the shift report contains the results obtained this shift in the areas of production, productivity and availability of equipment. The shift report is produced automatically, by the Monitor computer in the dispatch office, at the end of each shift.

Detailed performance information is made available to mine planning staff without the time consuming effort of time and motion studies. Finally, these results can be fed directly to external computers for Accounting or Management Information services. A third microcomputer, identical to the Monitor micro and linked to the computers in the dispatch office through a

networking facility, is used to provide current operating results for the guidance of mine management. It runs a program set called Reporter that adds shift results to historic information files and updates a large number of report files.

Access to management information is achieved through a Viewer program, running on the same computer. Mine management has the capability, through the terminal network, to set a comprehensive series of performance indicators on request. PMCS provides a wide range of management information, in graphic or tabular form.

A feature of the system is its ability to measure and report on the results it has achieved. A baseline, or actual results achieved in key performance areas during a normal pre-implementation period, is established. Viewer program displays these baselines along with current operating results in its graphs and reports.

Vehicle Location Systems

Several Automatic Vehicle Location (AVL) systems are being built. Krakiwsky et al (1987a) define the functions of such systems based on the following tasks:

- vehicle position recording using satellite signals and differential positioning devices,
- call up a digitized electronic map of the area,
- plot the position of the vehicle on CRT screen, and
- obtain instructions using a knowledge based expert system to optimize travel distance between two points.

AVL systems are defined as an assembly of technologies and equipment that permits determination, display and control of the vehicle movement in the field.

Krakiwsky et al (1987b) also define Stand-alone and Centralized AVL systems by providing an overview of the Stand-alone systems (Table 1) and Centralized systems (Table 2). The Centralized systems, preferred for mining application, are analysed here more in detail and are described as follows:

- The **Flair** (Fleet Location and Information Reporting) system was designed for the St. Louis Metropolitan Police Department. The positioning of the vehicle is accomplished by dead reckoning and map correlation known as the closed loop method. Multiple vehicles are tracked from information

Table 1. AVL Stand-Alone Systems

AVL SYSTEMS	HARDWARE							SOFTWARE				
	NAVIGATION SYSTEM	COMPUTER		INPUT FACILITIES	OUTPUT FACILITIES		ELECTRONIC MAP STORAGE	ZOOMING ALGORITHM	SPEECH ALGORITHM	OPTIMIZED ROUTE ALGOR.	POSITION / TRACK ALGORITHM	DATABASE / DISP. MANIP. ALGORITHM
		MICRO-PROCESSOR	MICRO-COMPUTER		CRT DISPLAY SCREEN	VOICE OUTPUT						
ETAK NAVIGATOR	closed loop dead reckoning	8088 chip	no	keypad	vector display	no	digitally encoded map cass.	yes	no	no	yes	yes
CARGUIDE	n/i	68000 chip	no	keyboard	video display	yes	bubble memory	yes	yes	divide and conquer	n/i	yes
VDO CITYPILOT	dead reckoning	yes	no	keyboard or light pen	yes	no	special map sheets	no	no	no	yes	no
MICROPILOT	dead reckoning		Apple II	keyboard and voice input	no	yes	storage in comp. mem.	no	yes	yes	yes	yes
AVL 2000 (Prototype)	GPS satellite positioning		Mac Plus	keyboard	vector display	no	hard disk MacPlus	yes	no	patch quilt concept	GPS point position	relational D.B.
AVL 2000 (First Gen.)[1]	GPS and dead reckoning	68000 chip	no	keyboard and voice input	vector display	yes	CD-ROM	yes	yes	patch quilt concept	GPS point position	relational D.B.
CHRYSLER : CLASS	GPS positioning		yes	finger touch control	colour video display	no	video disks	no	no	no	GPS point position	yes
NISSAN : CUE - X	satellite positioning		yes	keyboard	yes	no	n/i	no	no	no	yes	yes
ELECTRO GYRO-CATOR[2]	dead reckoning		yes	no	yes	no	photographic map storage	no	no	no	dead reckoning	no
BUICK : QUESTOR[3]	no		yes	keyboard	colour graphics	no	digitally encoded tape cass.	no	no	no	yes	yes
FORD TRIPMONITOR	dead reckoning & sat.system		yes	finger touch control	colour graphics	no	n/i	no	no	no	yes	yes
PHILIPS CARIN	dead reckoning	yes	no	keyboard	yes	yes	CD-ROM	no	yes	yes	yes	yes
BOSCH / BLAUPUNKT	dead reckoning		yes	keypad	simpli. graphics	yes	EPROM and CD-ROM	no	yes	yes	yes	yes
DAIMLER - BENZ	n/i	2 - 6801 chips	yes	keyboard	yes	no	n/i	no	no	yes	n/i	yes
NAVIGATOR	uses database to coordinate road network	2 - 6801 chips	no	keyboard	yes	yes	bubble memory	no	yes	yes	no	yes

1 expert system concept implemented
2 maps are overlaid onto display screen
3 navigation program on cassettes

Table 2. Centralized AVL Systems

AVL SYSTEMS	HARDWARE										SOFTWARE			
	NAVIGATION SYSTEM	COMPUTER		INPUT FACILITIES			OUTPUT FACILITIES			MAP STORAGE	OPTIMAL ROUTE ALGORITHM	AUXILARY ROUTE ALGORITHM	POSITION / TRACK ALGORITHM	DATABASE / DISP. MANIP. ALGORITHM
		BASE UNIT	MOBILE UNIT	BASE UNIT	MOBILE UNIT	ROADSIDE UNIT	BASE UNIT	MOBILE UNIT	ROADSIDE UNIT					
FLAIR	dead reckoning	central processor	vehicle terrain nav data proc.	CP track-ing table	coded keypad		video disp.; radio trans.	trans./ receiv.		map database stored in central proc.	no	yes	yes	yes with zoom capab.
MAGNAVOX	dead reckoning and TRANSIT satellite syst.	IBM PC-AT	MX - 6102 terrain nav	keyboard, VHF-FM trans./rec.	same as base unit		colour graph.; trans./ receiv.	trans./ receiv.		n/i	no	no	yes	yes
MOTOROLA	navigation done by driver	Motorola MDT data terminal	n/i	trans./ receiv.	trans./ receiv.		trans./ receiv.	trans./ receiv.		no	no	no	no	no
E MORROW	navigation done by driver	Motorola MDT data terminal	n/i	trans./ receiv.	trans./ receiv.		CRT & trans./ receiv.	CRT & trans./ receiv.		map storage in data terminal	no	no	no	yes
AVL 2000 mining	TRANSIT satellite system	mini-computer	micro processor		keyboard & lightpen	audio & digital message		CRT & voice	CRT & voice	database stored in central proc.	yes	yes	yes	yes
INDUCTIVE LOOP BASED GUIDANCE SYSTEM	proximity syst. (inductive loop buried in road)	n/i	n/i		key board	trans./ receiv. induct. loop		CRT display	induct. loop	map database stored in roadside unit	yes	no	no	yes
AUTOGUIDE	proximity syst. (electronic signposts)	central processor	route terminal		keyboard trans./ receiv.	radio beacon		CRT display & voice	radio beacon	map database stored in roadside unit	yes	no	no	yes

received via a radio frequency data terminal. Changes in vehicular directions are monitored by a directional gyro and a magnetometer. Distance is monitored with a magnetic pick-off odometer.

- The **Magnovox** Vehicle Location and Tracking system uses both dead reckoning and satellite positioning. Dead reckoning is done with a speedometer and fluxgate compass heading sensor to an accuracy of up to 2 % of distance travelled. Satellite positioning is by the Transit system to an accuracy of 200 m.
- The **Route-Tel** system is currently under development in the United Kingdom by SIA Computer Services. The concept is to allow a driver to access a terminal and key in the origin and destination of a proposed journey and receive a list of route instructions together with information on weather and hazard reports. The system does not operate in real time.
- The **Plessey Controls** system developed by UK Transport and Road Research Laboratory (TRRL) uses roadside markers at every major junction and transfers information to passing vehicles. An aerial assembly is mounted underneath the vehicle. Roadside units consist of a microprocessor based information system connected to an inductive loop buried in the road surface. This system mainly deals with the problem of traffic flow.
- The **Motorola** system is actually an electronic fleet management system using a data terminal communication network. No maps are used. The system is used by several taxi companies in North America.
- The **II Morrov** system is an electronic fleet management system. It displays major roads on a CRT screen for both the vehicle and dispatcher.
- The **Autoguide** system is an electronic route guidance system developed in UK and consists of two components: a route terminal set within the vehicle, and a central computer set at various locations (major intersections, etc.). The driver key in destination data and the central computer determines best route. The output is displayed on the route terminal or is given to the driver via an on-board voice synthesizer.
- The **AVL 2000** automatic vehicle location system (Fig. 3), was designed for open pit mining operation (Krakiwsky et al, 1987a). The hardware include a microprocessor, CRT display and microphone. The moving units have a positioning device on board, namely ranging, dead reckoning, GPS, a digital message device and a speech synthesizer.

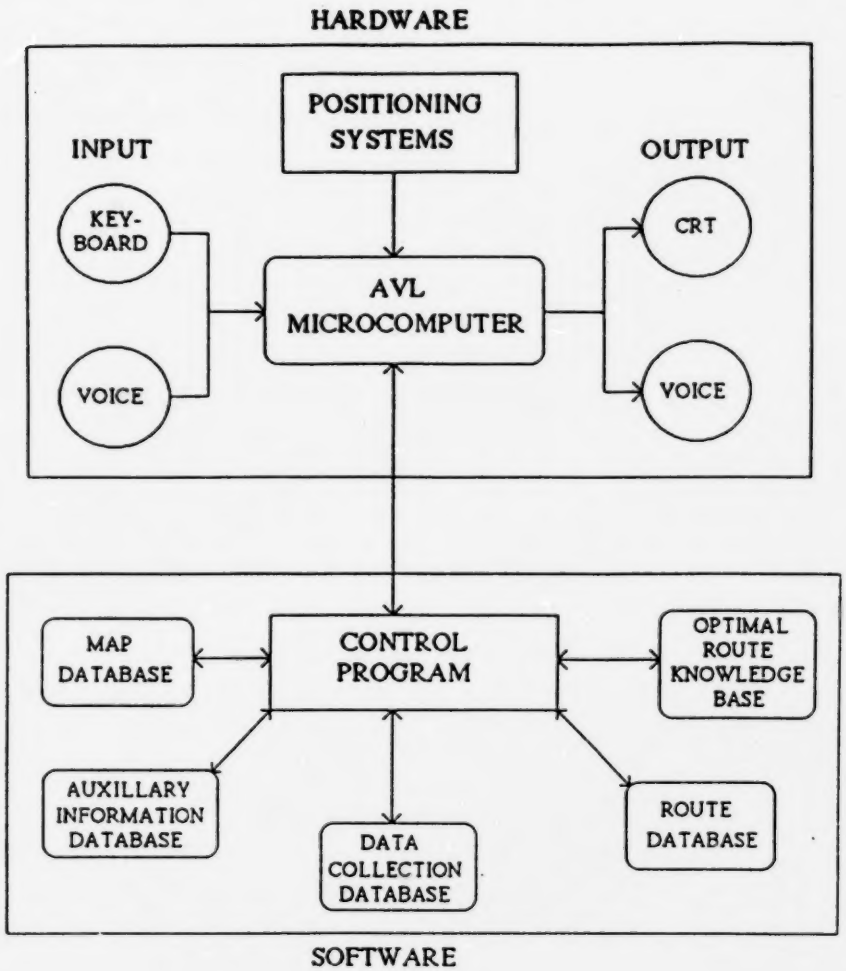

Fig. 3. AVL System Components

INTEGRATED TRUCK/SHOVEL MANAGEMENT SYSTEM

The Integrated Truck/Shovel Operating and Management System is in the initial stage of development and will be based on the Production Monitor and Control System (PMCS). The Integrated Truck/Shovel Management System elements are shown in Figure 4. The project commenced in April 1988 and is planned to be complete in four years. The proposed system will incorporate several independent components into one integrated unit that will provide the dispatching function for mine operation, simulation function for mine planning, and vital sign monitoring for mine maintenance. The information provided by the various components will be interrelated. The mine manager will be in position to accurately assess the operating problem in the mine, having wide spectrum of information than ever before. The components of the system are:

1. Computer Simulation Program.

   This program is intended for short to medium term production scheduling and should continually accept and process on-site generated data. The program is expected to be developed in several modules that may be used independently. It will accept real time data generated and collected by the mine site equipment information system and drive the dispatching program.

2. Dispatching program.

   This program should dispatch trucks in real time in accordance with mine site policies. It is proposed that the dispatching system be set up at the beginning of each shift, monitor truck/shovel performance in relation to this basic set-up, and reassign in keeping with specified mine site requirements. This system must allow for user interaction at anytime, and provide trend information as specified by the user.

3. Equipment Information System.

   This system is expected to monitor relevant operating, maintenance and equipment performance data and feed this data for further processing in simulation and dispatching programs. Types of data covered by this information system are expected to be defined by the users and may include operating and maintenance data.

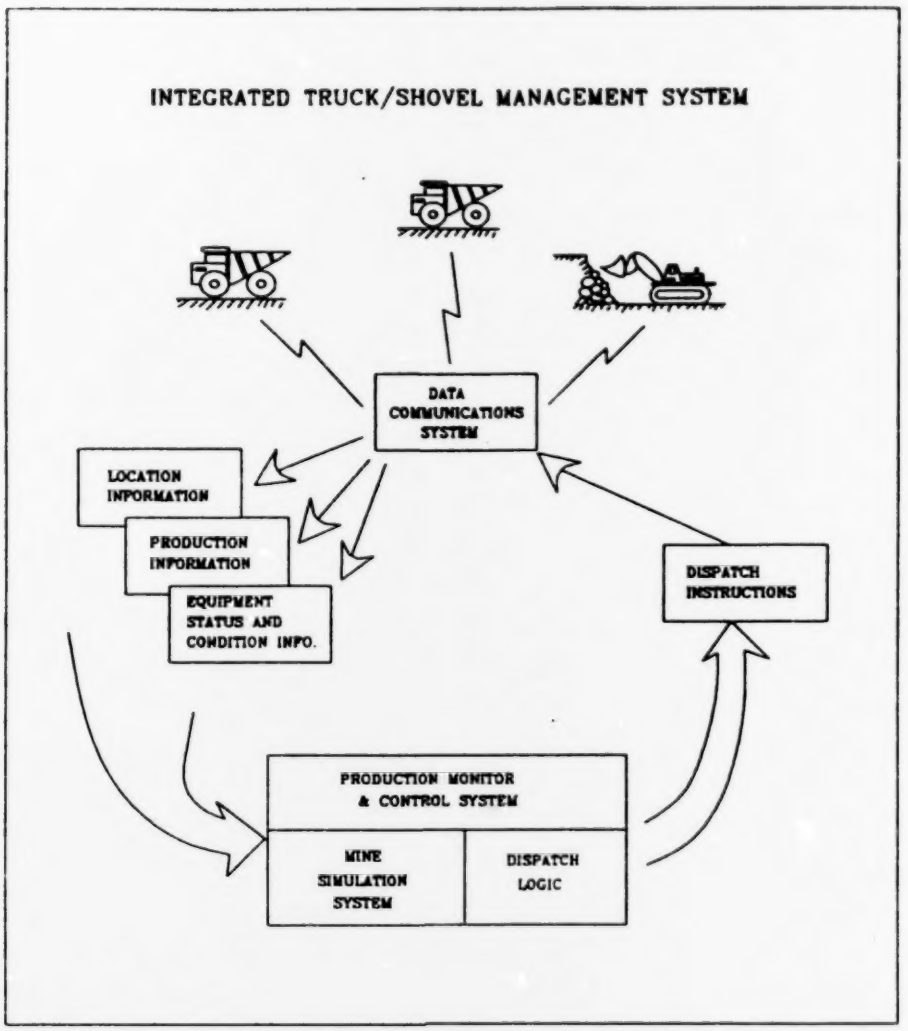

Fig. 4. PMCS Integrated System Components

4. Data Transfer System.

A radio based two way communication system that can send monitored information to a central computer for processing, and relay dispatch decisions as well as provide voice communication is proposed. This system must also have the abillity to provide temporary on-line storage of data for "on-demand" transmission and further processing.

5. Mobile Equipment Location Devices.

This hardware and program software will locate and continuously update equipment location using satellite or terrestrial based facilities. This system is defined as an assembly of technologies and equipment that permits centralized and automatic detection and display of the position and movement of vehicles through an area. The results of this system component will be integrated into the simulation program that drives the dispatching module.

6. Data Base System.

This component is the heart of the system. It must facilitate effective storage and retrieval of the data for a variety of purposes not limited to those included in this technology demonstration program.

In essence the computer simulation program will take equipment information and location system outputs relayed by the data transmission system, conduct simulations, apply the logic of the dispatch program and inform equipment operators of dispatch decisions.

The central computing facility may also subject the collected data to other analyses to provide operating, management and maintenance information.

At present WENCO (Int.), Vancouver, B.C., CANMET and a group of industrial partners are defining objectives to be achieved by each system component, and are revieving all available options for each system component (cost and benefit) before recommending the preferred option.

In parallel the group is preparing a detailed work plan for both bench and field testing of all components on a stand alone basis. Following that testing the individual components will be integrated, installed, commissioned, validated and will operate in one or more producing mine for a period of at least 12 months.

CONCLUSION

In the presented paper a program to select, develop and test an integrated truck/shovel management system is described.

The integrated truck/shovel management system is believed to be the most comprehensive truck/shovel monitoring system proposed to date and when completed, the system will be an advanced, but simple, computer based system that will significantly enhance mine productivity and reduce costs by improved understanding and utilization of existing resources. Flexibility is being retained so that further developments can be easily incorporated.

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